Europeans, and the probability is great that the plant itself is a native of this hemisphere. In being carried to other countries it was taken beyond the reach of both the friends and the enemies which had developed with it. The boll weevil has migrated northward with the extension of the area of cotton cultivation into Mexico and Texas, but the ant has not yet followed. The question now is whether it can be induced to do so. The Mexican entomologists seem not to have found the ant in that country, in the northern states of which the weevil has been reported as very destructive.

That the ants are so localized in their distribution in this part of Guatemala has undoubtedly served the better to demonstrate their value as protectors of the cotton plant; it suggests also, with other facts, the probability that they are not native here, but have spread eastward in smaller or larger colonies as the forests were cleared away by the Indians. The present occupation of the eastern districts of Alta Vera Paz by the Indians does not date back more than a few generations, though abundant evidence of much more ancient inhabitants is found in the apparently primeval forests. The ants, like the Indians, probably came from the dry, open interior plateau region, where the center of the aboriginal cotton industry of Guatemala is still located, and where another visit to the ants is to be paid in the next few days. To establish such an origin for this useful insect would greatly increase the probability of its successful introduction into the United States. The acclimatization of a thoroughly tropical animal requiring continuous heat and humidity could scarcely be hoped for. If, however, the cotton ant can survive a long dry season and perhaps cold weather in the table lands of Guatemala it might easily learn to hibernate in Texas, as has the boll weevil. The ant, indeed, is much better able to protect itself against frost, since it excavates a nest three feet or more into the ground. That it is a reasonably hardy insect is shown also by the fact that several individuals have survived confinement for twelve days without food, and seem now to be thriving on a diet of cane juice. To take worker ants to Texas will be, evidently, a very easy matter, but to secure queens and establish permanent colonies may require considerable time and experiment, and a thorough study of all the habits of the species.

Although the cotton seems to be especially adapted to attract the ant by means of its numerous nectaries, the insect is not, like some of the members of its class, confined to a single plant or to a single kind of prey. It was observed running about on plants of many different families, and it attacks and destroys insects of every order, including the hemiptera, and even centipedes. On the other hand, it does not do the least injury to the cotton or to any other plant, as far as has been ascertained, and it can be handled with impunity, having none of the waspish ill-temper of so many of the stinging and biting ants of the tropics. Since where once established it exists in large numbers and seeks its prey actively, it is a much more efficient destroyer of noxious insects than the spider or the toad. It seems, in short, not unlikely to become a valued assistant in the agriculture of tropical and sub-tropical countries, if not in temperate regions. The farmer has a new and practical reason to 'consider the ant.'

An accumulation has been made, of course, of seeds, specimens, photographs and notes bearing on the cotton, beetles, ants and many other collateral matters not to be mentioned here. Even this brief preliminary report should not close, however, without an acknowledgment of the many favors of Messrs. Owen and Champney, owners of the Sepacuite estate, and of Mrs. Owen. Without the kind invitations, hospitality and extensive local knowledge and cooperation of these generous friends, it would have been quite impracticable to visit the Indian cotton district of the interior of Alta Vera Paz in 1902, or to ascertain the existence of the cotton ant in the present season.

O. F. Cook.

Sepacuite, Guatemala,
May 11, 1904.

Zygospore Formation a Sexual Process.

In a paper now in process of publication the writer has given a detailed account of a

somewhat extended investigation on the method of reproduction in one group of the common molds, and since many of the facts which have been discovered are at variance with the conclusions of other investigators, and since the problems involved have a general biological interest, it has seemed desirable to publish the following preliminary summary of the more important results obtained.

Among the Mucorineæ, as is well known, the usual form of reproduction is by means of non-sexual spores in sporangia, while the sexual method by means of zygospores is unknown in the great majority of species, and even where it has been reported our knowledge of its occurrence in about four fifths of the cases is based on the recorded observations of single individuals. For over thirty years the phenomena of reproduction by zygospores in these plants have been an object of considerable investigation among students of fungi, and as a result a number of conflicting theories have arisen as to the significance of the process and the conditions by which it is induced. Such conclusions as have been reached have in general been based on the assumption that external conditions of one kind or another were the essential factors concerned, and, while the process has been generally regarded as a primitive type of sexual reproduction, some investigators have denied that any sexuality is involved in zygospore formation.

In the experimental investigations made by the present writer in order to determine the conditions associated with zygospore production in more than a dozen different species, results have been obtained which may be summarized as follows:

Zygospore production in the Mucorineæ is conditioned by the inherent nature of the individual species and only secondarily or not at all by external factors.

According to their method of zygospore formation, the various species among the Mucorineæ may be divided into two main categories, which may be designated as *homothallic* and *heterothallic,* and which correspond respectively to monœcious and dicœcious forms among the higher plants.

In the homothallic group, zygospores are developed from branches of the same thallus or mycelium and can be obtained from the sowing of a single spore. Although it has been currently assumed that all mucors belong to this class, it comprises but a very small percentage of the species and contains the only forms from which heretofore it has proved possible to obtain a constant production of zygospores. *Sporodinia grandis,* the only common species, is very frequent on decaying agarics, etc., and has served as a basis for experimentation in a majority of the investigations dealing with this subject.

In the heterothallic group, comprising a large majority of the species, zygospores are developed from branches which necessarily belong to thalli or mycelia diverse in character, and can never be obtained from the sowing of a single spore. Every heterothallic species is, therefore, an aggregate of two distinct strains through the interaction of which zygosporic reproduction is brought about. If inoculations of these two opposite strains of a given species are so disposed that their mycelia can grow together, there will be developed, at the region of contact, a distinct dark line produced by the accumulation of zygospores formed between filaments of the opposite strains. *Rhizopus nigricans,* the common bread mold which is used by nearly every elementary class in cryptogamic botany, may be taken as the type of this group. An accidental mixture of its two strains has been kept under cultivation for nearly ten years and as the 'Harvard strain' has furnished zygospores for class work to many botanical laboratories in this country.

In an individual species these sexual strains show in general a more or less marked differentiation in vegetative luxuriance, and the more and less luxuriant may be appropriately designated by the use of (+) and (—) signs respectively. In a few forms, no differentiation has been as yet detected; in others, one strain shows a less vegetative vigor when cultivated under unfavorable conditions; in the majority, however, the differentiation is evident from the marked difference in the gross appearance in cultures of the two opposite strains; and in one form, not only the habit of growth, but

the size of the spores are so diverse in the (+) and (—) strains that systematists generally would feel justified in describing them as separate species.

In heterothallic species, strains have been found which from their failure to react with (+) and (—) strains of the same form have been called 'neutral,' and a similar neutrality may be induced by cultivation under adverse conditions. A table under preparation to determine the relative abundance and distribution in nature of the (+), (—) and neutral strains of *Rhizopus* has so far shown that, although neutral strains are not uncommon, the majority of the cultures, obtained from various localities abroad and in this country, belong to either the (+) or the (—) strain.

In all species of both homo- and heterothallic groups in which the process of conjugation has been carefully followed, the swollen portions (*progametes*) from which the gametes are cut off do not grow toward each other, as currently believed, but arise as a result of the stimulus of contact between more or less differentiated hyphæ (*zygophores*) and are from the outset always normally adherent.

In some species the zygophores have been demonstrated to be mutually attractive (*zygotactic*).

In the *heterogamic* subdivision of the homothallic group, a distinct and constant differentiation exists between the zygophoric hyphæ and the gametes derived from them, but in the remaining homothallic forms and in all heterothallic forms no such differentiation is apparent. Thus, while in the heterothallic species the sexual difference inheres in the whole thallus of either strain, in the homothallic forms it is confined to the conjugating branches of a single thallus.

A process of imperfect hybridization will occur between *unlike* strains of different heterothallic species in the same or even in different genera, or between a homothallic form and *both* strains of a heterothallic species, and distinct white lines are produced in many cases at the regions of hybridization.

By taking advantage of this fact it has been possible to group together in two opposite series the strains of all the heterothallic forms under cultivation. When thus grouped, the (—) or less luxuriant strains will fall in one series, while the (+) or more luxuriant will be included in the other.

From the foregoing observations it may be concluded: (*a*) That the formation of zygospores is a sexual process; (*b*) that the mycelium of a homothallic species is bisexual; (*c*) while the mycelium of a heterothallic species is unisexual; (*d*) and further that in the (+) and (—) series of the heterothallic group are represented the two opposite sexes.

The writer intends during the coming year to continue his investigations on the subject of sexuality in the lower fungi, and would be greatly indebted to any mycologists who might be willing to assist him by sending culture material of any of the forms of the Mucorineæ which may be found producing zygospores.

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On the Development of Palisade Tissue and Resinous Deposits in Leaves.

In connection with the experimental investigation of the causes of xerophily in bog plants, new evidence as to the factors involved in the development of palisade cells and resinous deposits has been obtained. It has been found possible, in the case of *Rumex Acetosella* L., to greatly modify its external appearance and internal structure by growing it under various ecological conditions. When grown in moist conditions, with soil and air temperatures approximately the same, the leaves attain a relatively large size and their tissues are exceedingly loose. A poorly developed palisade of one cell-layer and three layers of spongy parenchyma, beneath it, make up the mesophyll. The epidermis is composed of large turgid thin-walled cells, having a very delicate cuticle on the outside.

When grown on dry sand the leaves are notably thickened, reduced in size and the margins become revolute. The mesophyll is very compact and consists of a palisade of two to three cell-layers and a spongy tissue of two cell-layers. The epidermal cells are small and